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PRODUCTION EFFICIENCY OF RAINBOW TROUT DEPENDING ON THE TYPE OF FEED

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EKONOMIČNOST PROIZVODNJE DUŽIČASTE PASTRMKE U ZAVISNOSTI OD VRSTE KORIŠĆENE HRANE

Abstrakt

Dužičasta pastrmka (*Oncorhynchus mykiss*) predstavlja dominantnu hladnovodnu vrstu ribe u komercijalnom gajenju na području Balkana, zbog relativne tolerantnosti na kolebanja kvaliteta vode i brzog rasta. Pastrmka se intenzivno gaji u kaveznom sistemu sa osnovnim ciljem postizanja maksimalnog prirasta uz što niže troškove hrane.

U radu su predstavljeni razultati ekonomičnosti proizvodnje dužičaste pastrmke u uslovima kaveznog gajenja u zavisnosti od tipa i cijene korišćene hrane na bazi rezultata iz eksperimenta sa upotrebom šest različitih vrsta hrane u kaveznom ribogojilištu „Tropic ribarstvo" na jezeru Bočac, u 2 ciklusa po 90 dana (ukupno 180 dana) i 6 tretmana/ciklusu. Računat je parcijalni koeficijent ekonomičnosti riblje hrane u šest tretmana, kao odnos vrijednosti ostvarenog prirasta ribe i troškova upotrebljene hrane za svaki od šest kaveza posebno, za dva proizvodna ciklusa (jesen-zima i proljeće-ljeto).

U jesenje-zimskom režimu ishrane najveća parcijalna ekonomičnost riblje hrane ostvarena je u 2. tretmanu (E_{pm}=3,51), koji potvrđuje da se na 1 KM troškova riblje hrane ostvaruje 3,51 KM po osnovu ostvarenog prirasta ribe. Gotovo istu ekonomičnost je imala i hrana u 6. tretmanu. Hrana u 2. tretmanu izbila je na prvo mjesto zbog povoljnog faktora konverzije, a hrana u 6. tretmanu zbog najniže cijene. Najmanje ekonomična hrana je bila ona korišćena u 1. tretmanu (E_{pm}=2,29).

U proljetno-ljetnom režimu ishrane potrošnja riblje hrane i prirast mase ribe su bili intenzivniji. Najpovoljniji parcijalni koeficijent ekonomičnosti riblje hrane u ljetnom periodu ostvaren je (ponovo) u 2. tretmanu (E_{pm}=3,07 odnosno recipročno E_{pm}=0,33). Iako je ovaj koeficijent niži nego u jesenje-zimskom periodu, treba imati u vidu da je ostvareni prirast mase pastrmke, a time i ukupan prihod, u proljetno-ljetnom periodu 2,5 puta veći nego u jesenje-zimskom periodu. Na drugom mjestu po isplativnosti je hrana u 3. i 4. tretmanu čija primjena u jesenje-zimskom periodu nije bila isplativa, dok je najmanje ekonomična bila hrana korišćena u 1. tretmanu (E_{pm}=2,45 odnosno recipročno E_{pm}=0,41).

Proizvodnja ribe u uslovima intenzivnog gajenja mora biti ekonomski isplativa da bi se održala na duži rok. Sa ekonomskog stanovišta najpovoljniji način ishrane ne mora biti onaj koji ima najniži faktor konverzije, isto kao ni onaj sa najjeftinijom hranom. To je potvrdio i eksperiment ispitivanja efikasnosti šest tipova riblje hrane u uslovima kaveznog uzgoja dužičaste pastrmke u različitim temperaturnim uslovima, koji kao optimalnu kombinaciju ishrane preporučuje onu sa najpovoljnijim odnosom vrijednosti oswtvarenog prirasta ribe i troškove njene ishrane, uz pretpostavku nepromjenljivosti svih ostalih troškova proizvodnje.

Ključne riječi: *dužičasta pastrmka, riblja hrana, ekonomičnost proizvodnje.*

INTRODUCTION

One of the ways to increase bioproductivity of water resources is the intensive cultivation of fish in cages. Rainbow trout (*Oncorhynchus mykiss*) is the dominant type of coldwater fish in the commercial growing in the Balkans, due to the relative tolerance to fluctuations in water quality and rapid growth. The main objective of the intensive growing of fish is to achieve maximum growth with minimum cost, and critical analysis used the food which is the major portion of the costs (Hardy, 1989). Determining the food in aquaculture, it is evident that it is one of the more expensive animal feed on the market, because of higher nutritional content and it is produced by using expensive processes (extrusion, pelleting). Nutritional and biological efficiency of feed for salmonids is constantly improving, and its share makes fish meal and high-quality power components that contain a high amount of usable energy. Food with high content of digestible nutrients (40-45% SP-CP and 20-30% SM-DM) results in a conversion ratio from 1 to 1.2, even below 1 (Bureau, 2004).

MATERIAL AND METHODS

The aim of this paper is to analyze the production efficiency of rainbow trout in cage farming conditions depending on the type (content of fat and protein) and the cost of feed used. Experiment with 6 different types of nutrients is carried out in a cage fish farm "Tropic Fishing" - Lake Bocac, at 2 cycles per 90 days (180 days) and 6 treatments per cycle. The first cycle was carried out in the autumn-winter 2005/06, and another in spring-summer 2006 cages in production volume of 162.5 m^3/cage. Average weight of rainbow trout at the beginning of the cycle was 95.3 grams, and second cycle 96.1 grams. Set on a 400 kg fish/treatment, a total of 2,400 kg/cycle. Used the 6 types of extruded fish feed (Table 1), 3 mm grit (Savic, 2008).

Table 1. Composition of feeds in experiment

Nutritients/treatment	1.	2.	3.	4.	5.	6.
Crude protein/crude fat, SP/SM (%)	44/14	48/26	42/22	42/23	44/26	42/18
Total energy (MJ)	20,4	23,8	21,8	22,3	23,2	21,0
Digestible energy (MJ)	17,7	21,9	19,3	20,3	20,9	19,1
Metabolizable energy (MJ)	15,7	19,6	17,4	18,3	18,9	17,2
Nitrogen free extract (NFE) %	21,0	17,0	15,0	17,2	13,0	21,5

Statistical data processing (8400 fish) included the arithmetic mean, coefficient of variation, analyzing the impact of the growing season and type of nutrients on the growth of body weight by two-factorial model, 2x6 (Statistical Analysis-ANOVA).

Production efficiency is an indicator of the relationship between actual performance and used elements of production to achieve this effect. In the elements of production, there are occurring three primary factors: labor, capital goods and materials, so the efficiency can be measured as partial efficiency of: labor, capital goods or materials (Andric, 1998, Berberovic, Todorovic, 2009). Fattened trout in cage breeding system assumes the same expenditure of capital goods and labor, the research focused on only one factor of production - fish food and its consumption and costs (similar like Vasko, Drinic, 2009). For this reason, the determination of the economic effect of using different types of food made by calculating the coefficient of partial material efficiency (E_{pm}) for each type of fish food, and especially their mutual comparison of two different feeding regimes. Partial efficiency ratio was determined from the ratio of increment fattened trout and value of food in each of the six treatments.

Besides food, significant material cost of fattening of trout is a fish fry. Its quantity (400 kg) and cost were the same for all treatments, so it is logical that the value of production valued only for the achieved gain weight of fish as a result of the use of fish food during the experiment. Production value was evaluated as the product of gain weight and prices of fish. To acualize the results of the analysis in relation to the time of performing the experiment in the model the current prices of cleaned trout in early 2011 have been taken into consideration in the market of Banja Luka (8 BAM/kg). As in the case of the selling price of fish, in the model, there were used the current retail market price of the appropriate type of fish franco-Banja Luka (1.85 to 2.83 BAM/kg). Consumption of fish food was not the same in all six cages because of its different energy values, but also not the same in the autumn-winter and spring-summer regime fattening as a result of different temperature regimes of water.

RESULTS AND DISCUSSION

The low water temperatures in autumn-winter period affect the lower level of the diet that causes fewer effects of nutrients on growth of rainbow trout. Drop in water temperature does not affect the growth dynamics of change in the relationship of mass and type of nutrients, nutrients in treatment 2 and 5 have more evident effects on the growth of body mass, but does not cause significant differences in mean body weight compared to other treatments.

Table 2. Efficiency of trout production in autumn-winter nutrition regime

Diet in spring-summer		Treatment					
Element		1.	2.	3.	4.	5.	6.
1.	Avg. body weight at the beginning (g)	96,28	94,75	97,95	94,29	94,56	93,97
2.	Coeff. var. body mass at the beginning	16,83	22,99	19,39	22,63	19,65	21,59
3.	Avg. body mass at the end (g)	125,23	131,50	131,60	128,26	131,47	127,35
4.	Coeff. var. body weight at the end	24,75	22,93	21,53	23,56	19,60	19,69
5.	The total mass at the beginning (kg)	400	400	400	400	400	400
6.	The total mass at the end (kg)	516,3	551,7	534,2	540,8	553,8	539,9
7.	Total fish weight gain (kg)	116,3	151,7	134,2	140,8	153,8	139,9
8.	Price of fish (BAM/kg)	8,00	8,00	8,00	8,00	8,00	8,00
9.	The value of increment of fish	930,6	1.213,7	1.073,2	1.126,4	1.230,6	1.119,0
10.	Quantity of feed (kg)	172,4	138,9	172,4	172,4	138,9	172,4
11.	The coefficient of conversion	1,48	0,92	1,29	1,22	0,90	1,23
12.	Price of feed (BAM/kg)	2,36	2,49	2,50	2,13	2,83	1,85
13.	The costs of feed (BAM)	406,9	345,9	431,0	367,2	393,1	318,9
14.	Partial coefficient of efficiency (E_{pm})	2,29	3,51	2,49	3,07	3,13	3,51
		0,44	0,28	0,40	0,33	0,32	0,29

Biggest partial efficiency of fish food has been achieved in the second treatment, although the economy had virtually the same feed in the 6th treatment. Feed in the second treatment emerged in the first place because of the favorable conversion factors, and the feedd in the 6th treatment for the lowest prices. This example illustrates that a conclusion about the viability of the use of fish feed based on the lowest conversion factor would not be right because the most favorable factor in the 5th treatment, but also the feed is the most expensive. The least favorable option is in the first treatment, because the conversion factor is high, and feed expensive. Significant differences in mean body mass in spring-summer period, under the influence of different foods, come to the fore the growth of water temperature >9^{o}C . Season of feed and type significantly influence the high differences in mean values ($p>0,01$) of mass of rainbow trout, as well as interactive relationship of rainbow trout as well as interactive showing the high degree of dependence ($p>0,01$) of growth of body mass of the season and type of feed nutrients.

The low water temperatures in autumn-winter period, affecting the lower level of the diet that causes fewer effects of nutrients on growth of rainbow trout. Drop in water temperature does not affect the growth dynamics of change in the relationship of mass and type of nutrients, nutrients in treatment 2 and 5 have more obvious effects on the growth of body mass, but does not cause significant differences in mean body weight compared to other treatments.

Table 3. Production efficiency of trout in cage in spring-summer diet regime

Diet in spring-summer		Treatment					
Element		1.	2.	3.	4.	5.	6.
1.	Avg. body weight at the beginning (g)	94,08	97,32	95,04	99,43	96,33	94,39
2.	Coeff. var. body mass at the beginning	21,19	20,14	27,76	21,68	21,56	24,20
3.	Avg. body mass at the end (g)	167,67	191,84	192,01	185,26	195,95	161,23
4.	Coeff. var. body weight at the end	18,03	25,35	19,59	23,54	18,15	22,42
5.	The total mass at the beginning (kg)	400	400	400	400	400	400
6.	The total mass at the end (kg)	713,6	781,0	800,8	741,5	808,1	680,2
7.	Total fish weight gain (kg)	313,6	381,0	400,8	341,5	408,1	280,2
8.	Price of fish (BAM/kg)	8,00	8,00	8,00	8,00	8,00	8,00
9.	The value of increment of fish	2.508,4	3.048,3	3.206,3	2.732,3	3.265,0	2.241,9
10.	Quantity of feed (kg)	433,6	398,6	433,6	433,6	398,6	433,6
11.	The coefficient of conversion	1,38	1,05	1,08	1,27	0,98	1,55
12.	Price of feed (BAM/kg)	2,36	2,49	2,50	2,13	2,83	1,85
13.	The costs of feed (BAM)	1.023,3	992,5	1.084,0	923,6	1.128,0	802,2
14.	Partial coefficient of efficiency (E_{pm})	2,45	3,07	2,96	2,96	2,89	2,79
		0,41	0,33	0,34	0,34	0,35	0,36

In spring-summer dietary, consumption of fish food and fish weight gain were more intense. The most favorable partial coefficient of efficiency of food fish in the summer period was realized (again) in the second treatment (3.07 or reciprocal 0.33). Although this coefficient is lower than in autumn-winter period, we should bear in mind that the achieved weight gain of trout, and thus the total income, in the spring-summer period, 2.5 times higher than in autumn-winter period. The second most cost effectiveness is the food in the 3 and 4 treatment, whose application of the autumn-winter period was not profitable. In the spring-summer it is the least economically viable to use the fish food that was used in the first treatment. From the standpoint of the results from Table 3 it should be emphasized the observation that the cheapest food is not necessarily the best solution for breeding fish, because the food in 6 treatment was the cheapest, and from the stand point of conversion and fish increment was the worst. Generally, the conclusion is that during the year for breeding trout in conditions similar to those which are characterized by experimental conditions are most favorable to use food that has been used in the second treatment. As an alternative to the autumn-winter period was equally profitable food used in the sixth, and in spring-summer period it is approximately the cost-effective food used in the third and fourth treatment. For the realized cost of production of rainbow trout in cage conditions thee were not comparative results found in the available local literature. Similar studies on the economic efficiency (profitability) for fish production were found in foreign literature (Ugvumba and Okoh, 2010, Bozoglu et al., 2009, Kudi et al., 2008), but it is mainly related to other fish species and farming systems.

CONCLUSIONS

Even the cheapest fish food, or the lowest conversion factor do not have to provide the most favorable economic results in the fattening of fish. This is confirmed by the example of experiment in fattening rainbow trout in cage system using six different types of food. The coefficient of conversion of food in the autumn-winter conditions ranged between 0.90 and 1.48, while the spring-summer conditions between 0.98 and 1.55. Food prices ranged from 1.85 to 2.83 BAM/kg. Economic efficiency of production is measured using the partial coefficient of efficiency as the relative values of gain and cost of fish feed used. In autumn-winter conditions of growing the largest coefficient of efficiency (E_{pm2}=3.51) had the food used in treatment 2, although it is not even the cheapest food or food with the lowest conversion ratio. The same food was confirmed as the most cost-effective and economical spring-summer conditions of the experiment (E_{pm2}=3.07) in which the consumption of food and fish growth were more intense than in autumn-winter period.

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